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Site Evaluation for Application of Fuel Cell Technology

U.S. Naval Academy, Annapolis, MD

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Construction Engineering
Research Laboratory

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Foreword

In fiscal years 93 and 94, Congress provided funds for natural gas utilization equipment, part of which was specifically designated for procurement of natural gas fuel cells for power generation at military installations. The purchase, installation, and ongoing monitoring of 30 fuel cells provided by these appropriations has come to be known as the "DOD Fuel Cell Demonstration Program." Additional funding was provided by: the Office of the Deputy Under Secretary of Defense for Industrial Affairs & Installations, ODUSD (IA&I)/HE&E; the Strategic Environmental Research & Development Program (SERDP); the Assistant Chief of Staff for Installation Management (ACSIM); the U.S. Army Center for Public Works (CPW); the Naval Facilities Engineering Service Center (NFESC); and Headquarters (HQ), Air Force Civil Engineer Support Agency (AFCESA).

This report documents work done at U.S. Naval Academy, Annapolis, MD. Special thanks is owed to the the U.S. Naval Academy points of contact (POCs), Lt. Kathy Stewart and Chi Chiu, for providing investigators with access to needed information for this work. The work was performed by the Energy Branch (CF-E), of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Michael J. Binder. Part of this work was performed by Science Applications International Corp. (SAIC), under Contract DACA88-94-D-0020, task orders 0002, 0006, 0007, 0010, and 0012. The technical editor was William J. Wolfe, Information Technology Laboratory. Larry M. Windingland is Chief, CEERD-CF-E, and L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Gary W. Schanche. The Acting Director of CERL is William D. Goran.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Director of ERDC is Dr. James R. Houston and the Commander is COL James S. Weller.

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1 Introduction

Background

Fuel cells generate electricity through an electrochemical process that combines hydrogen and oxygen to generate direct current (DC) electricity. Fuel cells are an environmentally clean, quiet, and a highly efficient method for generating electricity and heat from natural gas and other fuels. Air emissions from fuel cells are so low that several Air Quality Management Districts in the United States have exempted fuel cells from requiring operating permits. Today's natural gas-fueled fuel cell power plants operate at electrical conversion efficiencies of 40 to 50 percent; these efficiencies are predicted to climb to 50 to 60 percent in the near future. In fact, if the heat from the fuel cell process is used in a cogeneration system, efficiencies can exceed 85 percent. By comparison, current conventional coal-based technologies operate at efficiencies of 33 to 35 percent.

Phosphoric Acid Fuel Cells (PAFCs) are in the initial stages of commercialization. While PAFCs are not now economically competitive with other more conventional energy production technologies, current cost projections predict that PAFC systems will become economically competitive within the next few years as market demand increases.

Fuel cell technology has been found suitable for a growing number of applications. The National Aeronautics and Space Administration (NASA) has used fuel cells for many years as the primary power source for space missions and currently uses fuel cells in the Space Shuttle program. Private corporations have recently been working on various approaches for developing fuel cells for stationary applications in the utility, industrial, and commercial markets. Researchers at U.S. Army Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL) have actively participated in the development and application of advanced fuel cell technology since fiscal year 1993 (FY93), and have successfully executed several research and demonstration work units with a total funding of approximately $55M.

As of November 1997, 30 commercially available fuel cell power plants and their thermal interfaces have been installed at DoD locations, CERL managed 29 of these installations. As a consequence, the Department of Defense (DoD) is the

owner of the largest fleet of fuel cells worldwide. CERL researchers have developed a methodology for selecting and evaluating application sites, have supervised the design and installation of fuel cells, and have actively monitored the operation and maintenance of fuel cells, and compiled "lessons learned" for feedback to manufacturers. This accumulated expertise and experience has enabled CERL to lead in the advancement of fuel cell technology through major efforts such as the DoD Fuel Cell Demonstration Program, the Climate Change Fuel Cell Program, research and development efforts aimed at fuel cell product improvement and cost reduction, and conferences and symposiums dedicated to the advancement of fuel cell technology and commercialization.

This report presents an overview of the information collected at U.S. Naval Academy, Annapolis, MD along with a conceptual fuel cell installation layout and description of potential benefits the technology can provide at that location. Similar summaries of the site evaluation surveys for the remaining 28 sites where CERL has managed and continues to monitor fuel cell installation and operation are available in the companion volumes to this report (see Table 1).

Objective

The objective of this work was to evaluate the U.S. Naval Academy as a potential location for a fuel cell application.

Approach

On 13 and 14 October 1994, Science Applications International Corporation (SAIC) visited the U.S. Naval Academy (the site) located in Annapolis, MD to investigate it as a potential location for a 200 kW phosphoric acid fuel cell. This report presents an overview of information collected at the site along with a conceptual fuel cell installation layout and description of potential benefits. The Appendix to this report contains a copy of the site evaluation form filled out at the site.

Table 1. Companion ERDC/CERL site evaluation reports.

Location	Report No.
Fort Bliss, TX	TR 01-13
Fort Eustis, VA	TR 00-17
Fort Huachuca, AZ	TR 00-14
Fort Richardson, AK	TR 00-Draft
Picatinny Arsenal, NJ	TR 00-24
Pine Bluff Arsenal, AR	TR 01-15
U.S. Army Soldier Systems Center, Natick, MA	TR 00-Draft
U.S. Military Academy, West Point, NY	TR 00-Draft
Watervliet Arsenal, Albany, NY	TR 00-Draft
911th Airlift Wing, Pittsburgh, PA	TR 00-18
934th Airlift Wing, Minneapolis, MN	TR 00-19
Barksdale Air Force Base (AFB), LA	TR 01-29
Davis-Monthan AFB, AZ	TR 00-23
Edwards AFB, CA	TR 00-Draft
Kirtland AFB, NM	TR 00-Draft
Laughlin AFB, TX	TR 00-Draft
Little Rock AFB, AR	TR 00-Draft
Nellis AFB, NV	TR 01-31
Westover Air Reserve Base (ARB), MA	TR 00-20
Construction Battalion Center (CBC), Port Hueneme, CA	TR 00-16
Naval Air Station Fallon, NV	TR 00-15
Naval Education Training Center, Newport, RI	TR 00-21
Naval Hospital, Marine Corps Base Camp Pendleton, CA	TR 00-Draft
Naval Hospital, Naval Air Station Jacksonville, FL	TR 01-30
Naval Oceanographic Office, John C. Stennis Space Center, MS	TR 01-3
Subase New London, Groton, CT	TR 00-Draft
U.S. Naval Academy, Annapolis, MD	TR 00-22
National Defense Center for Environmental Excellence (NDCEE), Johnstown, PA	TR 01-33
Naval Hospital, Marine Corps Air Ground Combat Center (MCAGCC), Twentynine Palms, CA	TR 01-32

Units of Weight and Measure

U.S. standard units of measure are used throughout this report. A table of conversion factors for Standard International (SI) units is provided below.

1 ft	=	0.305 m
1 mile	=	1.61 km•
1 acre	=	0.405 ha
1 gal	=	3.78 L
°F	=	°C (X 1.8) + 32

2 Site Description

The U.S. Naval Academy is located in Annapolis, MD. The Site has been designated as an Energy Showcase facility. The university consists of a broad range of buildings including offices, dormitories, classroom facilities, a hospital, laundry, athletic facilities and cafeterias. Temperatures at the Site range from the teens to 100 °F.

A total of five separate applications for a 200 kW fuel cell were investigated during the Site visit. After investigation of load data and discussions with Site personnel, four of the applications were eliminated from consideration. These include:

1. *Hospital.* This building was eliminated for lack of sufficient space to site the fuel cell.
2. *Central Heating Plant (CHP).* The CHP's high temperature hot water loop supplies heat throughout the Academy. The hot water loop is very tight and requires very little make-up water. This application represented less than 10 percent thermal utilization of the fuel cell output.
3. *Laundry.* Based on limited water consumption data, fuel cell thermal utilization would be less than 30 percent, which is not adequate for an Energy Showcase application.
4. *Dormitory DHW load.* Over 4,000 students reside in the main dormitory complex. The hot water load is used over a short period throughout the day, which would require significant storage. Additionally, the hot water distribution system is divided into eight separate sections, reducing significantly the opportunity to maximize fuel cell thermal utilization.

The thermal application selected for the fuel cell is the galley, which serves an average of 12,000 meals per day throughout most of the year. Galley personnel begin around 2:30 a.m. and do not finish until around 10:00 p.m. The galley is supplied hot water from two main storage tanks, which are heated by the central hot water loop.

Site Layout

Figure 1 shows the site layout for a portion of the dormitory facility and the galley. Natural gas, sanitary, storm sewer and electrical underground lines are shown in the parking areas. The galley boiler room lies along a long corridor. The corridor ceiling has conduit and hot water piping where fuel cell interface pipe could be located.

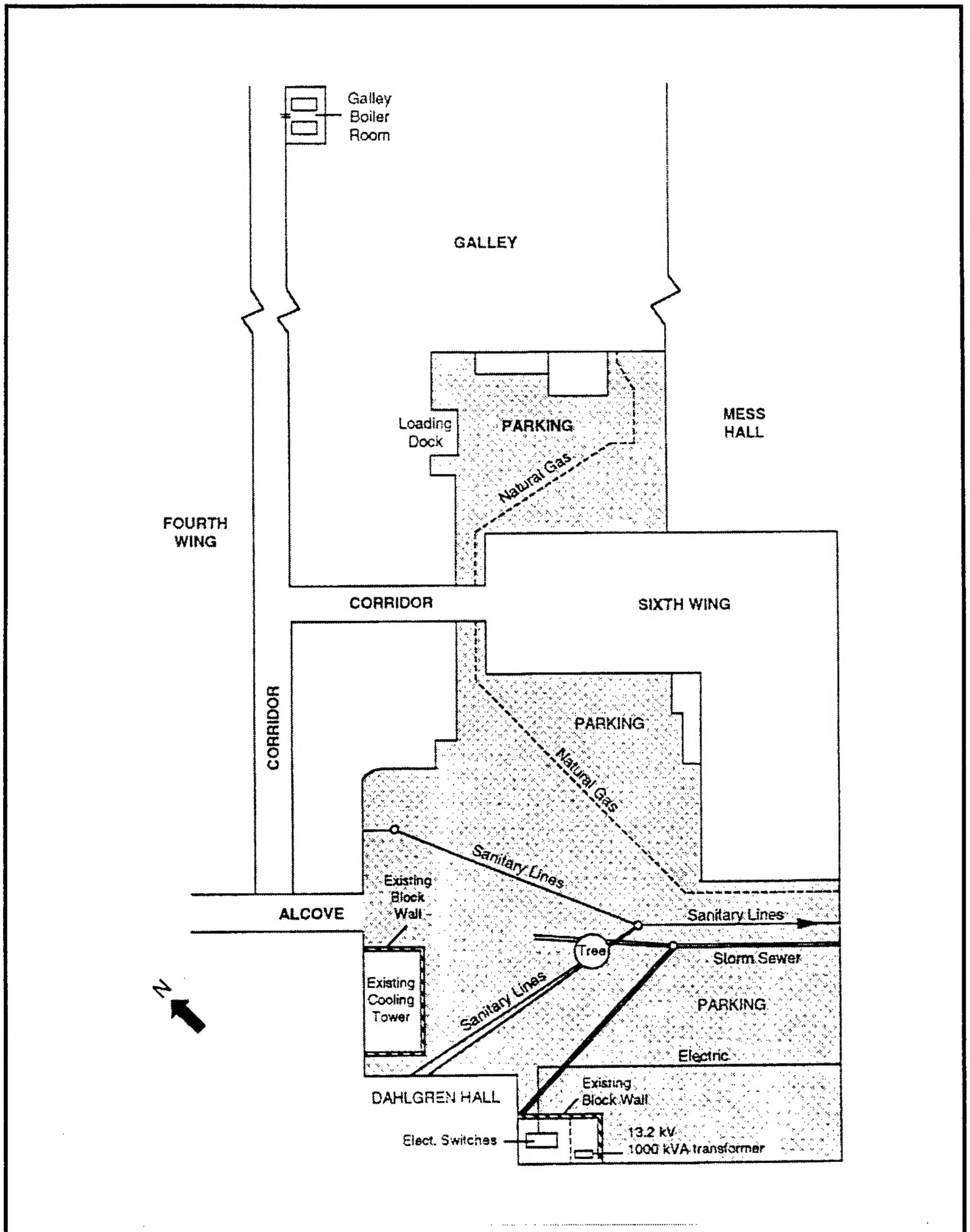

Figure 1. U.S. Naval Academy Dormitory/Gallery site layout.

Electrical System

An electrical transformer is located behind a block wall at the south end of the parking lot and is rated at 13,200/480 (1,000 kVA). The electrical switch gear is also located inside the block wall area.

Steam/Hot Water System

Hot water for the dormitory facility and galley is heated using the Site's high temperature hot water loop. The hot water goes out at about 450 °F and returns to the central plant at around 350 °F. Several instantaneous heat exchangers exist throughout the dormitory facility. The galley boiler room has two storage tanks heated by heat exchangers from the central hot water system.

Space Heating System

Space heating is achieved through heat exchangers in individual dorm wings.

Space Cooling System

There are no absorption chiller connected to the central plant hot water loop.

Fuel Cell Location

The proposed location for the fuel cell is the southwest corner of the parking lot next to an existing cooling tower. This is the only area nearby where the fuel cell could be sited. To site the fuel cell at this location, about four parking spaces next to the tree would have to be removed to move the driving area away from the proposed fuel cell area.

Figures 2 and 3 show the location and layout of the proposed fuel cell site. The electrical connection is about 70 ft from the fuel cell. The thermal piping run will be approximately 450 ft into the galley boiler room. The thermal interface piping (preheated city water only) would be run into the building and down the long corridor. The natural gas will be brought across the parking lot (approximately 100 ft).

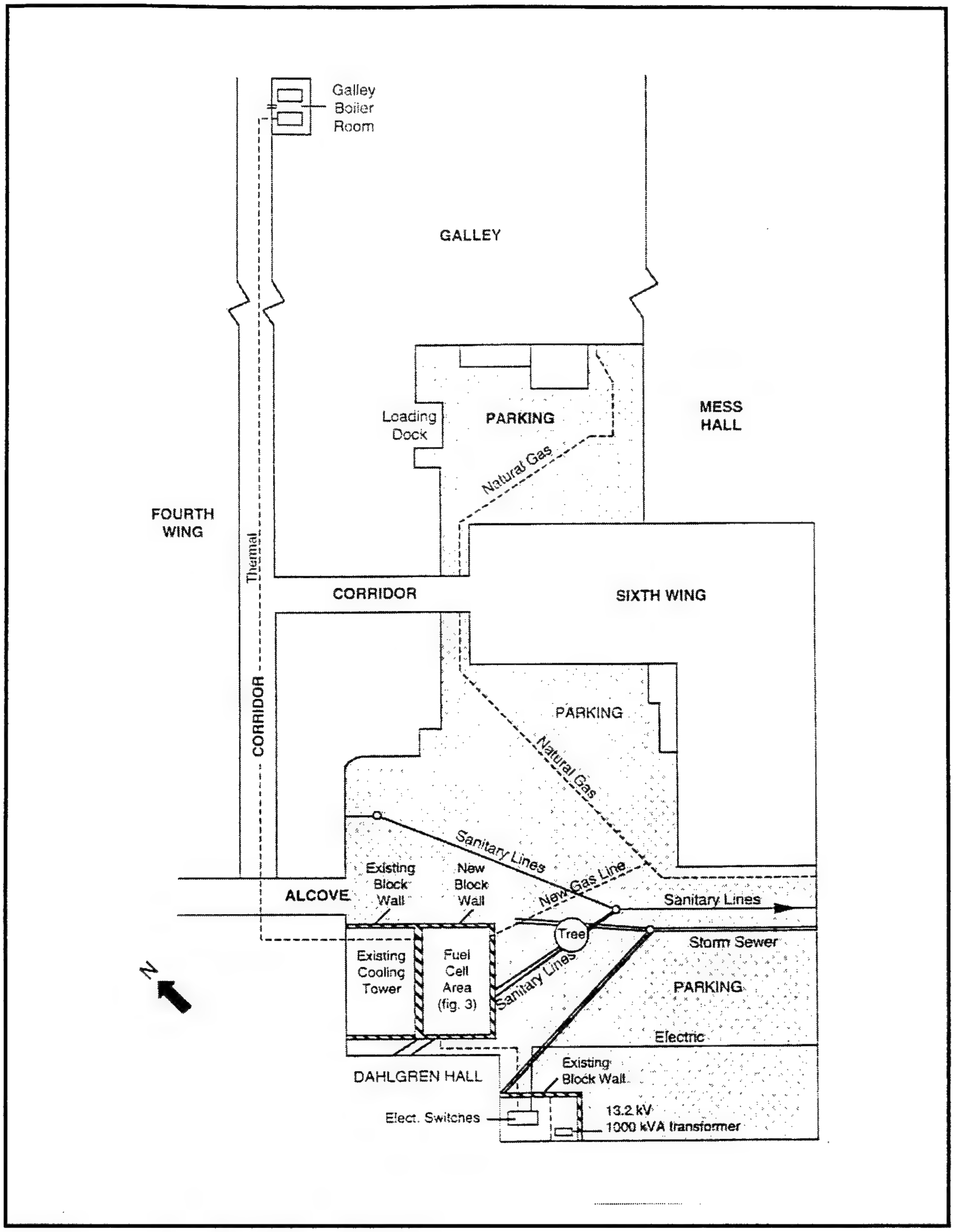

Figure 2. U.S. Naval Academy fuel cell location.

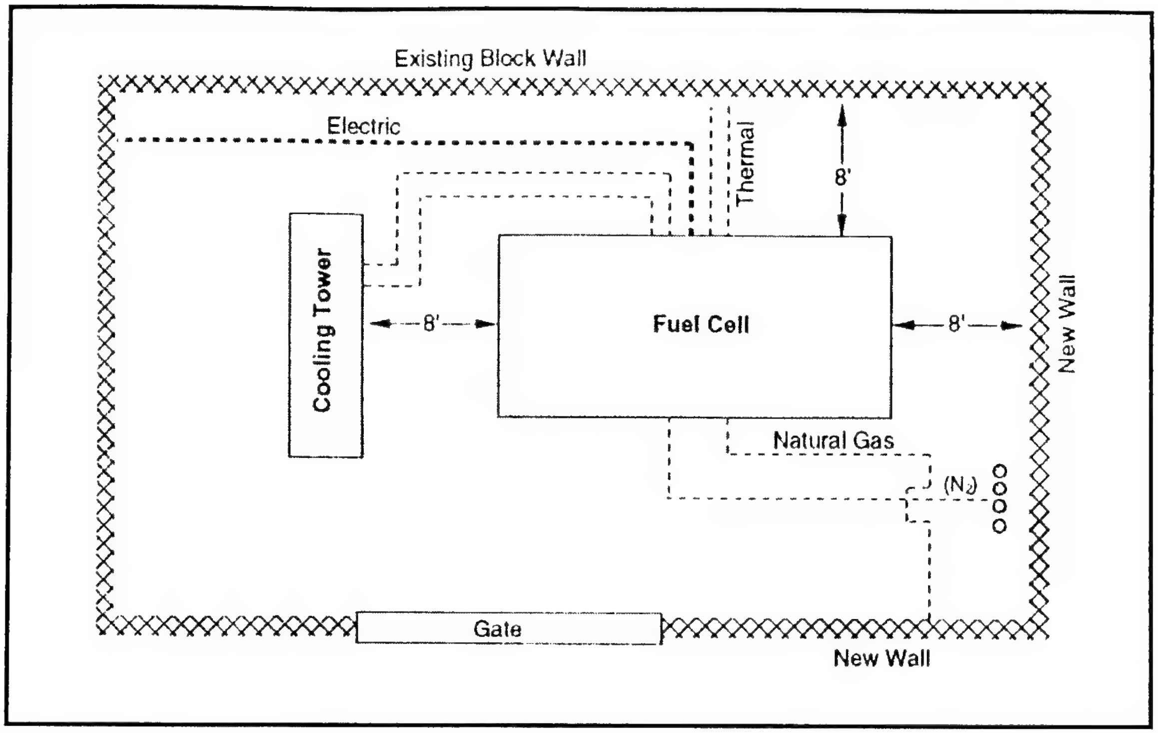

Figure 3. Fuel cell layout.

Fuel Cell Interfaces

The electrical output of the fuel cell should be connected to the 480 volt side of the 13,200/480 volt transformer as shown in Figure 2. This transformer is rated at 1,000 kVA.

The recommended thermal interface for the fuel cell is to heat the hot water used by the galley. The galley serves breakfast, lunch, and dinner 7 days a week. For 10 months of the year, an average of 4,000 meals are served three times a day. For roughly 2 months of the year 400 meals are served three times a day. To estimate the hot water load and daily load profile, the following assumptions were made:

- 2.4 gal/meal/day (ASHRAE)
- 150 °F maximum fuel cell supply temperature
- 55 °F city water temperature.

The daily hot water load for the galley is calculated as follows:

<u>For 10 months/year</u>

(2.4 gal/meal/day)(12,000 meals/day)(8.35 lb/gal)(150 °F-55 °F) = 22.8 MBtu/day

For 2 months/year

(2.4 gal/meal/day)(1,200 meals/day)(8.35 lb/gal)(150 °F-55 °F) = 2.28 MBtu/day

The galley serves breakfast from 7-8 a.m., lunch from 11-12 noon and dinner from 6-7 p.m. It was assumed that the dishwashers run for 3 hr following each meal and that the dishwasher hot washer usage was 2.5 times greater than other galley uses. Figure 4 shows the daily hot water usage profile, using these assumptions.

The average hot water load is 690 kBtu/hr without the dishwashers operating and 1,730 kBtu/hr with the dishwashers operating. Figure 5 shows the proposed thermal interface for the fuel cell without storage. Thermal utilization without hot water storage is calculated as:

For 10 months/year

(690 kBtu/hr)(10.5 hr/day) + (700 kBtu/hr)(9 hr/day) = 13,545 kBtu/day

13,545 kBtu/day / (700 kBtu/hr * 24 hr/day) = 81% thermal utilization

For 2 months/year

2.28 MBtu/day / 700 kBtu/hr * 24 hr/day) = 14% thermal utilization

81%(10/12) + 14%(2/12) = 70% annual thermal utilization without storage

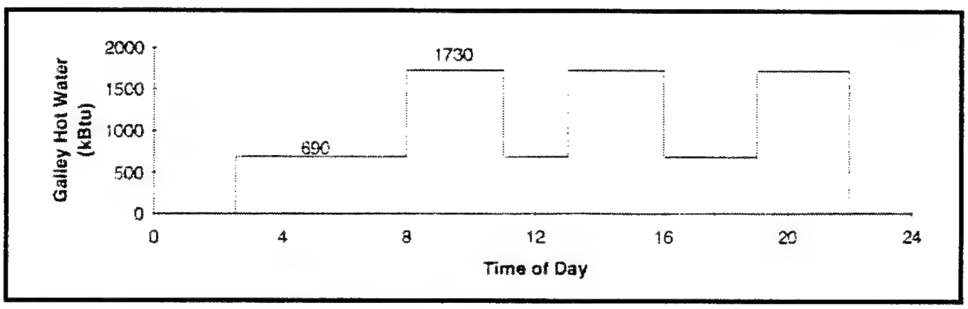

Figure 4. Daily hot water usage profile.

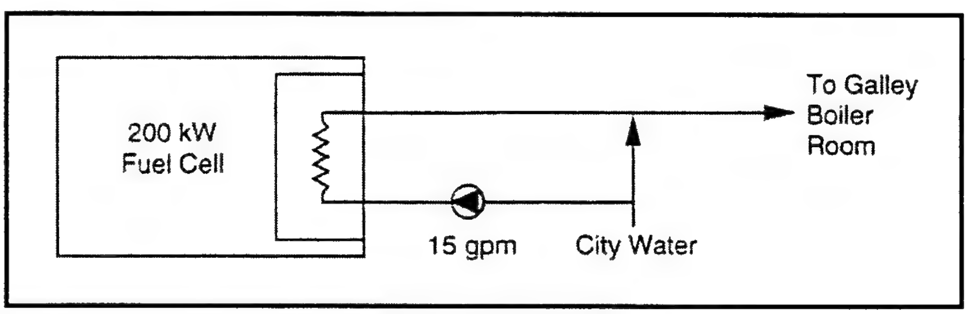

Figure 5. Fuel cell thermal interface without storage.

The 70 percent thermal utilization could be optimistic because the 690 kBtu/hr of thermal is an average estimate and no actual load data was available. When the thermal load goes above 700 kBtu/hr, the fuel cell would not be able to meet the entire demand without a newly installed storage tank.

Because the Site is an Energy Showcase, maximum thermal utilization is desired. A storage tank could be added to increase the amount of fuel cell thermal output used by the galley. The fuel cell would charge the storage tank from 10:00 p.m. to 2:30 a.m.. The stored hot water would then be used to supplement the fuel cell output during times of high thermal demand (dishwashers 8-11 a.m., 1-4 p.m., 7-10 p.m.). This proposed thermal interface with storage is shown in Figure 6. The city water is fed through a pump (15 gpm) to the fuel cell. If make up water at greater than 15 gpm is required, the balance will flow through the fuel cell hot water storage tank to the galley boiler room.

Assuming that the fuel cell can recharge a storage tank for 4.5 hr per day (between 10:00 p.m. and 2:30 a.m.), the largest storage tank size would be 4,050 gal (15 gpm * 60 min./hr * 4.5 hr/day). Two storage tank sizes were evaluated for this application; full storage (4,050 gal) and half storage (2,025 gal) cf. Table 2. The assumptions made in the analysis are a 15 gpm flow rate, 700 kBtu/hr maximum fuel cell thermal output, 150 °F maximum storage tank temperature and no storage required for 2 months of the year. Calculate annual thermal utilization with storage as:

70% + [(Total Storage kBtu/day * 10/12) / (700 kBtu/hr * 24 hr/day)]

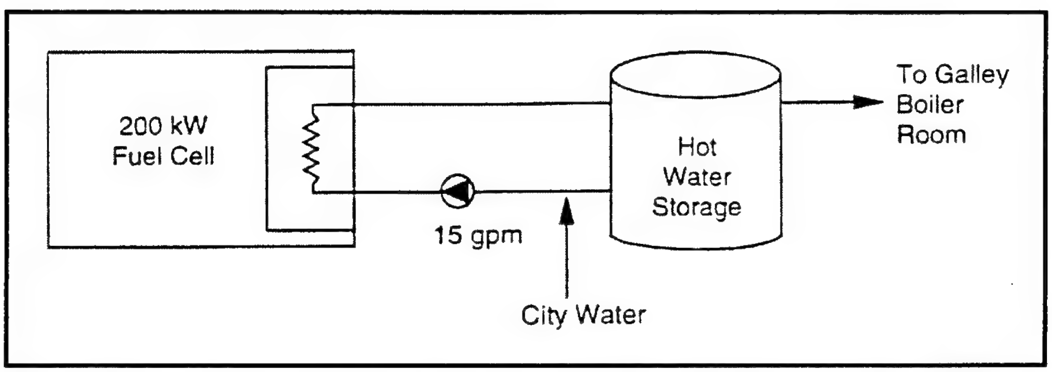

Figure 6. Fuel cell thermal interface with storage.

Table 2. Storage tank capacities.

Tank Size (gal)	Flow (gpm)	In (°F)	Out (°F)	KBtu/hr	Hr	Total kBtu/day	Annual Thermal Use
4050	15	55	150	700	4.5	3,150	86%
2,025	15	55	150	700	2.2	1,575	78%

3 Economic Analysis

The Site is located in the Baltimore Gas & Electric service territory. Electric bills were obtained for March 1993 through February 1994 (Table 3). The average rate ranged from 5.23 cents/kWh in October to 7.36 cents/kWh in June. The average electric rate paid by the Site during this period was 5.61 cents/kWh. The site is billed under rate schedule P, which is a time of use electric rate schedule. The on-peak period is from 10:00 a.m. to 8:00 p.m. on weekdays. The intermediate peak period is from 7:00 a.m. to 10:00 a.m. and 8:00 p.m. to 11:00 p.m. on weekdays. The off-peak period is all other times including weekday National holidays. The summer period is the 4 months from June through September and the nonsummer period is from October through May.

Table 3. U.S. Naval Academy electricity consumption.

Date	Peak KW	Total KWh	Total Bill	$/KWh
Mar-93	17,058	8,435,000	$391,591	$0.0464
Apr-93	17,519	7,938,000	$374,559	$0.0472
May-93	18,234	8,349,000	$441,808	$0.0529
Jun-93	22,288	9,681000	$712,956	$0.0736
Jul-93	22,716	11442,000	$781,032	$0.0683
Aug-93	24,006	11385,000	$807,713	$0.0709
Sep-93	22,846	9,544,000	$657,351	$0.0689
Oct-93	17,339	8,468,000	$357,964	$0.0423
Nov-93	16,628	8,359,000	$396,382	$0.0474
Dec-93	16,989	8,602,000	$408,993	$0.0475
Jan-94	17,557	8,987,000	$420,122	$0.0467
Feb-94	17,333	8,792,000	$414,460	$0.0471
Total/Avg	19,209	109,982,000	$6,164,930	$0.0561

The Site purchases natural gas from Baltimore Gas & Electric Company under rate schedules C (firm gas) and IS (interruptible large volume service). For the first 10,000 therms the Site pays a commodity charge of 16.3 cents per therm ($1.63/MBtu) and then 8.44 cents per therm ($0.844/MBtu) thereafter. Table 4 presents the gas costs for the central heating plant for FY93. The site paid an average of $3.77/MBtu during this period.

Table 4. U.S. Naval Academy natural gas consumption (Central Heating Plant).

Date	MBtu	Amount	$/MBtu
Oct-92	33,569	$102,299	$3.05
Nov-92	64,605	$170545	$2.64
Dec-92	63,880	$197,599	$3.09
Jan-93	20,745	$156,424	$7.54
Feb-93	—	$118,005	—
Mar-93	59,248	$197,658	$3.34
Apr-93	49,795	$146,535	$2.94
May-93	22,457	$99,288	$4.42
Jun-93	—	—	—
Jul-93	9,493	$10,917	$1.15
Aug-93	11,813	$69,938	$5.92
Sep-93	21,474	$77,471	$3.61
Total/Avg	357,079	$1,346,679	$3.77

Table 5 shows electric rate schedule P with time of use rates for summer and non-summer periods. It also calculates the electric savings for a 200 kW fuel cell operating at a 90 percent electric capacity factor and achieving full demand charge savings.

Table 5. U.S. Naval Academy—BG&E Rate Schedule P.

Demand Charge	Summer	Winter	
On-Peak ($/kW)	$12.09	$5.99	
Distribution ($/kW)	$2.33	$2.33	
	Energy Charge		
On-Peak ($/kWh)	$0.03790	$0.02257	
Mid-Peak ($/kWh)	$0.02742	$0.02037	
Off-Peak ($/kWh)	$0.01 468	$0.01174	
Fuel Charge ($/kWh)	$0.01 300	$0.01300	
On-Peak	806	1,693	28.5%
Mid-Peak	484	1,017	17.1%
Off-Peak	1 620	3,140	54.3%
	2,910	5,850	100.0%
	Savings/Year (90% ELF)		
On-Peak Energy	$5,499	$6,878	$12,377
Mid-Peak Energy	$2,389	$3,729	$6,118
Off-Peak Energy	$4,281	$6,635	$10,916
Fuel Charge ($/kWh)	$6,809	$13,689	
	$18,977	$30,931	$49,909
Demand (200 kW)	$11,536	$13,312	$24,848
Total Savings	$30,513	$44,243	$74,757
Average $/kWh	$0.0474		

Table 6 presents the results for a number of fuel cell energy savings scenarios. Four thermal utilization scenarios were evaluated: 100, 86, 78, and 70 percent. For electric demand reduction from the fuel cell, full demand savings, 50 percent demand savings and no demand savings scenarios were calculated. The results in Table 5 show net savings of $42,253 for the full thermal storage (86 percent) and full demand savings scenario. The no storage scenario (70 percent) had net savings of $37,815. The difference of $4,438 is the amount of savings attributable to thermal storage. Assuming a $5 per gallon pressurized tank, this would result in a payback period for the storage tank of 4.6 years.

The analysis is a general overview of the economics. For the first 5 years, ONSI will be responsible for the fuel cell maintenance. Maintenance costs are not reflected in this analysis, but could represent a significant impact on net energy savings. Since load profile data were not available, energy savings could vary depending on actual electrical and thermal utilization.

Table 6. Economic savings of fuel cell design alternatives (U.S. Naval Academy).

Case	ECF	TU	Displaced kWh	Displaced Gas (MBtu)	Electrical Savings	Thermal Savings	Nat. Gas Cast	Net Savings
A – Max. Thermal	90%	100%	1,576,800	7,357	$74,757	$27,736	$56,357	$46,136
A – Full Storage	90%	86%	1,576,800	6,327	$74,757	$23,853	$56,357	$42,253
A – 50% storage	90%	78%	1,576,800	5,738	$74,757	$21,634	$56,357	$40,034
A – No Storage	90%	70%	1,576,800	5,150	$74,757	$19,415	$56,357	$37,815
B – Max. Thermal	90%	100%	1,576,800	7,357	$62,333	$27,736	$56,357	$33,712
B – Full Storage	90%	86%	1,576,800	6,327	$62,333	$23,853	$56,357	$29,829
B – 50% storage	90%	78%	1,576,800	5,738	$62,333	$21,634	$56,357	$27,610
B– No Storage	90%	70%	1,576,800	5,150	$62,333	$19,415	$56,357	$25,391
C – Max. Thermal	90%	100%	1,576,800	7,357	$49,909	$27,736	$56,357	$21,288
C – Full Storage	90%	86%	1,576,800	6,327	$49,909	$23,853	$56,357	$17,405
C – 50% storage	90%	78%	1,576,800	5,738	$49,909	$21,634	$56,357	$15,186
C – No Storage	90%	70%	1,576,800	5,150	$49,909	$19,415	$56,357	$12,967

Assumptions:

Input Natural Gas Rate:	$3.77 /MBtu
Displaced Thermal Gas Rate:	$3.77 /MBtu
Displaced Electricity Rate:	LGS (TRANS.)
Fuel Cell Thermal Output:	700,000 Btu/hr
Fuel Cell Electrical Efficiency:	36%
Seasonal Boiler Efficiency:	75%

ECF = Fuel cell electric capacity factor

A = Full Demand Charge Savings

B = 50% Demand Charge Savings

C = No Demand Charge Savings

4 Conclusions and Recommendations

This study concludes that the galley represents the best thermal application for a 200 kW fuel cell at the U.S. Naval Academy. All the fuel cell electricity can be used at the Site by hooking up to the 13,200/480 volt transformer nearest the fuel cell. Thermal storage can add around $4,400 per year in savings using a 4,050 gal storage tank. The 4.6 year payback period is longer than most commercial applications would accept. The thermal piping run will be long (around 450 ft) but can be located in the corridor ceiling, thus eliminating significant trenching requirements.

Appendix: Fuel Cell Site Evaluation Form

Site Name: **U.S. Naval Academy**
Location: **Annapolis, MD** Contacts: **Chi Chiu**

1. Electric Utility: **Baltimore Gas & Electric** Rate Schedule: **P**
   Contact: **Kevin Bellamy**

2. Gas Utility: **Baltimore Gas & Electric** Rate Schedule: **C**
   Contact: **Kevin Bellamy**

3. Available Fuels: **Natural Gas /Fuel Oil** Capacity Rate:

4. Hours of Use and Percent Occupied:
   Gallery

Weekdays	5	Hr. 20
Saturday	1	Hr. 20
Sunday	1	Hr. 20

5. Outdoor Temperature Range: **teen - >100 °F**

6. Environmental Issues: **Fuel cell emissions expected to be lower than CT present standards**

7. Backup Power Need/Requirement: **One unit at Central Heating Facility**

8. Utility Interconnect/Power Quality Issues: **None**

9. On-site Personnel Capabilities: **Central plant personnel available on site. BG&E will provide service.**

10. Access for Fuel Cell Installation: **Proposed site is in open area of parking lot.**

11. Daily Load Profile Availability: **None**

12. Security: **Block wall to be constructed for aesthetics**

Site Layout

Facility Type: **Gallery** Age:

Construction: **Steel/Concrete**

Square Feet:

See Figure 1

Electrical System

Service Rating: **13.200 volts service distribution on base**

Electrically Sensitive Equipment:

Largest Motors (hp, usage):

Grid Independent Operation?:

Steam/Hot Water System

Description: **2 boilers for galley**

System Specifications:

Fuel Type: **Recirculating high temperature hot water loop**

Max Fuel Rate:

Storage Capacity/Type:

Interface Pipe Size/Description:

End Use Description/Profile:

Space Cooling System

Description: **No absorption chillers**

Air Conditioning Configuration:
Type:
Rating:
Make/Model:

Seasonality Profile: **No data available.**

Space Heating System

Description: **Heat exchanger in buildings**

Fuel:

Rating:

Water supply Temp:

Water Return Temp:

Make/Model:

Thermal Storage (space?):

Seasonality Profile: **none available**

Billing Data Summary

ELECTRICITY

	Period	kWh	kW	Cost
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10				
11.				
12.				

NATURAL GAS

	Period	Consumption	Cost
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10			
11.			
12.			

OTHER

	Period	Consumption	Cost
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10			
11.			
12.			

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14. ABSTRACT

Fuel cells are an environmentally clean, quiet, and a highly efficient method for generating electricity and heat from natural gas and other fuels. Researchers at the U.S. Army Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL) have actively participated in the development and application of advanced fuel cell technology since fiscal year 1993 (FY93). CERL has selected and evaluated application sites, supervised the design and installation of fuel cells, actively monitored the operation and maintenance of fuel cells, and compiled "lessons learned" for feedback to manufacturers for 29 of 30 commercially available fuel cell power plants and their thermal interfaces installed at Department of Defense (DoD) locations.

This report presents an overview of the information collected at U.S. Naval Academy, Annapolis, MD, along with a conceptual fuel cell installation layout and description of potential benefits the technology can provide at that location. Similar summaries of the site evaluation surveys for the remaining sites where CERL has managed and continues to monitor fuel cell installation and operation are available in the companion volumes to this report.

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